I. C. 7036

SEPTEMBER 1938

UNITED STATES
DEPARTMENT OF THE INTERIOR
HAROLD L. ICKES, SECRETARY

BUREAU OF MINES
JOHN W. FINCH, DIRECTOR

INFORMATION CIRCULAR

NECESSITY FOR MORE EXTENDED USE OF SAFETY EQUIPMENT IN MINING

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BY

D. HARRINGTON

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I. C. 7036,
September 1938.

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UNITED STATES DEPARTMENT OF THE INTERIOR - BUREAU OF MINES

NECESSITY FOR MORE EXTENDED USE OF SAFETY EQUIPMENT IN MINING[1]

By D. Harrington[2]

In recent years over 100,000 persons have been killed annually in the United States by accidents; about one-fifth of these have been workers in some of our industries; about one-third have been killed by motor vehicles; about another third have met death in home accidents, chiefly falls, burns, scalds, explosions, poisons, asphyxiations, suffocations, cuts, scratches, and so forth; and the rest have been killed in public accidents, excluding those caused by vehicles but including accidents on railroads or electric cars, drowning, and deaths by firearms and other means. Definite statistics on nonfatal accidents are not readily available, but at least 10,000,000 fairly serious accidents probably occur in the United States annually.

The latest industrial-accident statistics are obtainable from 1938 National Safety Council publications, in which annual industrial fatalities are divided about as follows (in round numbers): Agriculture, 4,500; trade and service, 4,500; construction, 3,100; transportation and public utilities, 2,900; manufacturing, 2,600; mining, quarrying, petroleum, etc., 1,900.

The exact cost of these 100,000 or more annual fatalities and 10,000,000 or more relatively serious nonfatal accidents, whether in misery or in cold-blooded dollars and cents, is not definite, nor will it ever be. That the cost is vitally consequent in our national life is beyond argument; and when it is realized that those probably best qualified by training and experience to give a well-balanced opinion believe that at least 80 percent, and perhaps as many as 90 percent, of such accidents, fatal as well as nonfatal, are preventable, and that at least 50 percent can be prevented by a relatively slight amount of well-directed effort, it is apparent that all of us have a problem to solve that is really worth our effort.

In 1930, H. W. Heinrich, of the Metropolitan Life Insurance Co., named $738,000,000 as the actual annual cost of compensable industrial accidents and somewhat over $5,000,000,000 as the total annual cost of all industrial accidents in the United States. In Arizona, one fatality cost an industrial concern more than $45,000 in compensation alone. One employer

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of large numbers of persons in mining and manufacturing has made an extensive study of the cost of noncompensable, "no-lost-time" accidents (so-called trivial accidents) and has placed the average cost to the company of each of these at $4 - the average daily wage when the study was made. A relatively recent survey of the coal-mining industry indicates that at least 10 percent of the cost of mining coal and placing it in railroad cars at the mine is chargeable to accidents.

For each of the past several years, approximately 20,000 lives have been lost and about 3,000,000 persons injured in American industrial plants; the causes have been numerous and, in at least some instances, more or less indefinite. Unquestionably, many such accidents, fatal and nonfatal, are caused directly or indirectly by mechanical equipment of some kind; it may be accepted as a certainty that the use of almost any kind of mechanical equipment in industrial work introduces its own hazards, though it may also remove or prevent others.

Mining has long been considered the most hazardous of the major lines of industrial endeavor. The latest statistics issued by the National Safety Council, those for 1937, indicate that, of 30 main industries in the United States, mining (including all types) had by far the worst severity rate, 9.42, compared with an average of 1.58 for the 30 industries. Lumbering had the next poorest rate - 4.62. In frequency, mining ranked 29th among the 30 industries listed, with a rate of 44.29, compared with the average of 13.85. Lumbering alone had a higher frequency rate than mining - 65.43. While accident statistics for mining are based on detailed data from only 145 of the several thousand mining plants in the United States, they indicate, at least generally, that in 1936 mining in the United States, notwithstanding a definite decrease in the rate of occurrence of mining accidents during the past several years, had an accident severity rate about 6 times and an accident frequency rate more than 3 times that of general industry. These figures roughly parallel accident occurrence in Great Britain, where the mining fatality rate indicated in relatively recent statistics is about 6 times that of general industry.

Having the poorest accident rate of the major industries of the United States gives mining a "black eye." The blackness is intensified by the fact that, according to the statisticians, the accident death rate in the United States as a whole is the poorest or worst of all of the leading nations of the world. Fortunately, this dark picture, like virtually all dark pictures, has redeeming features; otherwise, all of us might as well throw up our hands and join the already too great ranks of the fatalists, who believe that because mining is so inherently hazardous any attempt to prevent accidents in and around mines is merely a waste of time, money, and effort.

The following statistics, tabulated by the Bureau of Mines, give information that indicates definitely that safety conditions in mining have been improving slowly but steadily and that, although there is reason to

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believe that there was a recession in 1937 (as indicated by the sharp increase in the coal-mine accident rate in 1937), nevertheless the record for the past 5 years (including 1937) shows that safety in mines is improving.

TABLE 1. - Accident rates in metal mines, quarries, and coal mines in the United States, 1911-35, inclusive.

	Metal mines, killed and injured per thousand 300-day workers (calculated)	Quarries, killed and injured per thousand 300-day workers (calculated)	Coal mines, killed per million tons of coal produced
1911-15	202.38	91.58	4.76
1916-20	245.04	162.39	3.86
Average, 1911-20, incl.	224.36	123.84	4.27
1921-25, incl.	276.27	175.22	3.96
1926-30, incl.	213.22	140.77	3.75
1926	248.48	162.15	3.83
1927	224.64	164.55	3.73
1928	208.11	131.41	3.78
1929	203.14	129.79	3.59
1930	170.78	109.76	3.84
1931	142.09	106.04	3.31
1932	138.46	97.33	3.36
1933	155.13	97.59	2.78
1934	163.17	91.18	2.93
1935	152.86	86.23	2.925
1936	Not available	Not available	*2.72
1937	" "	" "	**2.98

* Tentative, but likely to be very close to the final figure.
** Tentative.

In this table, the fatal plus nonfatal accident rates per thousand 300-day workers in metal mines and quarries are given by various periods from 1911 to 1935, inclusive; as similar figures are not at hand for coal mines (nonfatal-accident data being unavailable, except since 1930), fatality rates per million tons of coal produced are given, since they are the most definite data procurable on accidents in coal mining.

It will be noted that the fatal plus nonfatal accident rate per thousand 300-day workers in metal mines varied relatively little in the 5-year periods from 1911 to 1930, the rate for the 5-year period 1926-30, inclusive, having been somewhat higher than for the 5-year period 1911-15, inclusive. A study of the lower part of the table, which gives the annual rates from 1926 to 1935, inclusive, indicates that the first real break in the metal-mining rate came in 1930, when for the first time it fell well below 200. After the break the improvement continued, the rate for 1931 having been lower than that for 1930 and the rate for 1932 having been slightly lower than that for 1931.

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In quarrying, the break from a high accident rate to a definitely lower one came in 1930, and since then every succeeding year has shown a slightly lower rate than that of its predecessor, although the rate for 1933 was slightly higher than that for 1932, which indicates that the industry has accident-prevention work well in hand.

In coal mines, the fatality rate per million tons of coal produced remained obstinately high after the considerable lowering of the rate from 4.76 for the 5-year period 1911-15, inclusive, to the much more favorable rate of 3.86 for the succeeding 5-year period 1916-20, inclusive. The rate hovered around or was slightly under 3.85 until 1931, when the lowest rate known until that year (3.31) was achieved. The 1932 rate of 3.36 failed to equal the excellent record of 1931 but was the next lowest rate so far; the rate for 1933 was 2.78, by all odds the lowest or best rate in the history of coal mining in the United States. Preliminary statistics for 1936 give a rate of 2.72, and when final data are assembled this probably will be found to be about correct, and is a lower rate than was achieved in any other year in the history of coal mining. Unfortunately, the tentative figures for 1937 indicate that the rate will be about 2.98, or higher than in any year since 1932, and final figures may bring the 1937 rate to above 3.00; but even so, 1937 probably will have a fatality rate lower than that of any year previous to 1932.

There is a more or less general impression that the rather heavy decrease in the accident rate in the mining industry during the past 5 or 6 years was due in large part to the decreased activity in the industry because of the depression. The rejoinder to those who believe this is that in the past periods of depression have been synchronous with increased accident occurrence, the recent depression having been an exception.

Notwithstanding the improvements shown in the above tabulation and discussion, our coal mines have been (and continue to be) more or less severely "under fire" because they have a much poorer accident rate on an exposure basis than have the coal mines of the more prominent coal-producing countries of Europe, as may be seen from table 2.

Column E gives the death rate per thousand workers adjusted to a year of 300 work days per employee, and it is very noticeable that the rate for the coal mines of the United States (bituminous and anthracite combined) for the 5-year period 1931-35 was 3.9357, or almost three times the rate (1.3454) for the coal mines of Great Britain for the same period, and, on the same basis, considerably more than three times the rate for Belgium (1.1340) and more than double that for Germany (1.8004) for the same period (1931-35). The rate for the coal mines of France for the 5 years 1930-34 (the latest figures available) was but 0.9507, or less than one-fourth the 1931-35 rate for the coal mines of the United States. None of these figures reflects credit upon the operation of the coal mines of the United States, and our coal-mining people have been very severely censured for the disregard for human life indicated by such statistics.

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TABLE 2. - Employment and accident data for coal mines in the United States and certain European countries

Year	Production short tons	Employees	Man-days	Killed	Death rate per 1,000 employees [1]	Average production per man per day short tons	300-day workers
	A	B	C	D	E	F	G
UNITED STATES (bituminous mines): 1931-35, incl.	1,757,182,875	2,195,804	366,430,747	4,797	3.9273	4.7954	1,221,436
UNITED STATES (anthracite): 1931-35, incl.	268,473,391	576,334	106,316,222	1,405	3.9645	2.5252	354,387
UNITED STATES (all coal mines): 1931-35, incl.	2,025,656,266	2,772,138	472,746,969	6,202	3.9357	4.2848	1,575,823
GREAT BRITAIN: 1931-35, incl.	1,237,783,093	4,079,075	1,002,070,000	4,494	1.3454	1.2352	3,340,233
FRANCE: 1930-34, incl.	275,596,507	1,295,460	325,958,630	1,033	.9507	.8454	1,086,529
BELGIUM: 1931-35, incl.	139,618,773	672,280	189,151,110	715	1.1340	.7381	630,504
GERMANY: 1931-35, incl.	644,159,540	1,439,753	414,229,000	2,486	1.8004	1.5550	1,380,763

1/ Adjusted to year of 300 workdays per employee.

Note. - The figures in columns A, B, C, D, and G are totals for 5 years.
If averages per year are desired, the totals as given should be divided by 5.

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At least part of the explanation for this sad state of affairs is to be found in the data contained in column F of table 2, which indicate that during 1931-35 the coal mines of the United States produced 4.2848 tons per man per day, or more than 3 times as much as the British coal miner (1.2352), 5 times as much as the French coal miner (0.8454), almost 6 times as much as the Belgian (0.7381), and nearly 3 times as much as the German (1.5550). Numerous factors are advanced as contributing to this much greater productivity of the coal miners of the United States, including our thicker coal beds, lesser depth of workings, extent of workings, etc., etc.; but unquestionably the major item in the vastly greater productivity of the coal mines of the United States, as contrasted with that of European coal mines, is the much greater extent to which the coal mines of the United States are mechanized, using the word in its broadest sense, including hauling, cutting, drilling, blasting, loading, etc., etc. There is also the very best of reasons to believe that the much greater accident rate among the coal miners of the United States should be attributed to the same reason as is their higher productivity, namely, the more extended mechanization in the coal mines of the United States as compared with those of Europe, and to the fact that the machinery is largely driven by electricity, with its known maximum efficiency as well as maximum hazard to workers.

Some years ago, the influence of mechanization in the occurrence of fatal accidents in the American coal industry was studied. In that survey the term "mechanization" was used in a broad sense rather than in the relatively narrow present-day interpretation, which is confined to mechanical equipment that displaces hand labor (especially for loading) at or in the working places. The above study indicated that over 25 years 2,000 or more lives had been lost annually by accidents in the coal mines of the United States, and that approximately 50 percent of those fatalities were caused by machinery or equipment of some kind; some of the blame could be laid upon defective or unsafe or unsuitable mechanical devices or equipment, some to misuse of the machinery or equipment, and some to causes induced by the presence or use of the machinery or equipment.

As evidence of the rapid increase of some phases of the hazard from "equipment" in coal mines, it is found that from 1910 to 1924 only about 7 1/2 percent of the explosion disasters in our coal mines were caused by electricity as the igniting agent; but in the four fiscal years July 1, 1927, to June 30, 1931, inclusive, out of 897 fatalities from explosions in the coal mines of the United States, 672 (74.8 percent) were due to explosions started by electricity.

Unquestionably much of the unsavory safety record of the mines of the United States is a reflection of the cynical attitude of our citizens, which is manifested in the utter disregard of some of them for human life and limb in their desire for speed and efficiency. This is manifest also in our very high mortality from murders and suicides and in the fact that we have the doubtful honor of leading the world in accidental deaths, especially those due to automotive equipment used (or largely misused) on our streets and highways. In other words, our mines pay the penalty for speed in operation owing largely to our progressiveness in mechanizing,

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just as our general populace pays a decidedly heavy penalty in life and limb in the transition from the slow-going horse and buggy to the swift and efficient automobile.

While much, probably most, of the criticism directed at our coal-mining people because of the excessive number of accidents that have occurred in the coal mines of the United States, as compared with those in European countries, is unjust when it is considered that the number of accidents of all kinds is far higher in the United States than in European countries; on the other hand, our mining people use mechanized methods and processes primarily to increase productivity and to reduce costs, and mere decency demands (or should demand) that only the safest kind of machinery and equipment be used in an industry that is known, or at least is believed, to be inherently the most hazardous of the major industries. Notwithstanding this fact, much, probably most, of the machinery and equipment in use in our mines is by no means the safest kind available.

In coal mining, for instance, some of the more progressive and far-seeing manufacturers of electrically operated machinery or equipment have cooperated with the Federal Bureau of Mines in devising and manufacturing what is termed "permissible" machinery or equipment, which can be used with relative safety in gassy or dusty mines, where the ordinary or "open" types of electrically-driven machinery or equipment are definitely dangerous. Statistics for four fiscal years indicate that 74.8 percent of the fatalities from explosions in American coal mines were charged to explosions in which electricity was the igniting agent; in every case, the electrical equipment or machinery that caused the ignition was of the "open" type, and not even in one instance was permissible equipment involved. Notwithstanding this fact, which is common knowledge among operating officials of most American coal-mining companies, it is amazing to find that relatively few of our coal mines are using permissible equipment. Such equipment is now available for almost every activity for which machinery is employed in a coal mine, as may be seen by consulting Bureau of Mines Information Circulars 6818 and 6845, which list the names of manufacturers and give other information on permissible machinery and equipment. Such machinery includes coal drills, undercutting, overcutting, or shearing machines, loading machines, conveyors, hoists, pumps, concrete mixers, electric switches, electric cap lamps, flame safety lamps, flashlights, telephones, locomotives, power trucks, and other equipment. When looking for the underlying reasons why readily available permissible equipment is passed by and the far less safe (and less durable and rugged) nonpermissible machinery and equipment is purchased and used, it is noted that very frequently the deciding factor is the slightly higher cost of permissible over nonpermissible types, which difference is sometimes as much as 20 percent.

One relatively recent American coal-mine explosion caused by a non-permissible machine unit cost 97 lives, another 195 lives, and another 82; in each instance the total money cost of the disaster to the operating company was little if any less than $1,000,000, yet the difference in price of a relatively safe permissible unit and a definitely unsafe nonpermissible

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one in each instance was hardly $1,000. This statement does not take into consideration the misery and hardships caused by the wholesale deaths of the victims of misguided purchasing; moreover, these three cases, while the worst examples available in connection with relatively recent disasters, do not by any means exhaust the instances of serious explosions caused by nonpermissible equipment and involving one or more deaths, and do not include numerous accidents(many fatal) due to the use of nonpermissible equipment and not in any manner concerned with explosions or fires.

In connection with the hazards of using nonpermissible electrical equipment in mines, it may be well to reiterate that so far as known there have been no explosions or fire disasters caused by permissible equipment; on the other hand, in addition to the above instances of fires and other disasters caused by nonpermissible equipment, dozens of other examples could be given, some with heavy loss of life, others with heavy loss of property, and still others with heavy loss of both property and life. Moreover, dozens of cases could be cited where nonpermissible equipment caused explosions or fires that entailed little actual loss, though potential hazards were dreadful to contemplate.

One consideration (in fact, the main one) in the failure of considerable numbers of users of mine electrical equipment to employ the permissible types has been the somewhat higher cost of permissible over nonpermissible equipment. In this connection it may be stated that a few progressive manufacturers of electrical mine equipment have announced that in the future they would make or market only permissible types, and presumably will furnish the safe equipment at a price equal to or at least comparable with that of nonpermissible equipment. These good intentions are likely to spread among manufacturers, and in the next few years purchasers of electrical mining equipment probably will be able to obtain only the safer, more rugged, and more serviceable permissible types. This will be a definite forward step in safe mining, though the permissible equipment is by no means foolproof or a cure-all, as its safety and efficiency depend upon currect installation, use with good judgment, and maintenance in good repair or, in other words, in permissible condition.

Although the most spectacular problems in mine safety probably will continue to be those connected with the causation, prevention, handling, and control of mine explosion and fire disasters, the real offenders that swell fatality lists in coal and metal mining are various kinds of accidents due to falls of men and material; approximately 50 percent of the mine fatalities of the United States over a period of years has come from these sources. Moreover, these causes are the most difficult to remedy and are those in which least progress probably has been made, the tentative rate of accident from falls of roof and coal for 1937 being 1.60 persons killed per thousand tons of coal produced and that for the 10-year period 1927-36, 1.608; therefore, progress has been essentially nil. This is not only disappointing but also surprising, because it is known that as the result of more extensive use of hard or safety hats numerous underground workers are now saved from serious accident or death. In fact, some safety experts

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place the number of lives saved through use of safety hats at 100 or more per year in the coal industry alone. The progress made in reducing the number of accidents from falls of roof through the use of the safety hats (and unquestionaly considerable benefit has been achieved) probably is nullified by some other means. For example, many serious, often fatal, accidents from falls of roof or coal occur at mechanized faces where posts or timbers are removed "temporarily" to allow manipulation of the mechanized equipment; overlying material then falls upon the workmen because replacement of supports is delayed too long.

Safety hats have aided materially in reducing coal-mine accidents, as is shown by the statement of a prominent western coalmine operator that in one instance with which he was familiar (a head injury that occurred before safety hats were invented and which could have been prevented by such a hat), the dollars-and-cents cost of the accident would have purchased safety hats for every coal miner in the State. A safety hat costs normally about $2.50 to $3.00, and the monetary cost of a fatality usually is at least $5,000 if both direct and indirect expense is included. If 100 lives are saved annually in coal mines by safety hats, the savings in money must be more than $500,000, or enough to purchase safety hats for about one-third of the coal miners of the United States; and if the annual savings entailed by the hundreds of nonfatal accidents now prevented by the use of safety hats were added, the total would purchase hard hats for at least 50 percent of our underground coal miners. It is estimated that not more than 50 percent of our miners are wearing safety hats, although it was recently announced that 90 percent of the West Virginia coal miners now use them.

The haulage-accident problem is almost as acute and as difficult to solve in mining as is the problem of automobile accidents on our streets and highways. Among the most hazardous features of the mine haulage problem (though by no means the only one) are the numerous unsafe conditions brought about by the use of the trolley system with its open, exposed, easily contacted wires that carry death-dealing electric current and cause arcing and sparking that readily ignite explosive gas or dust and initiated explosions and fires that have cost hundreds of lives and many millions of dollars in property loss. As with other hazardous equipment in use in mines, exact figures of the losses (humanitarian as well as financial) caused by the trolley haulage system are not available. If contact electrocutions, fatalities, and other accidents caused by men being "hit" by the trolley wire and then run over by cars or locomotives, fatalities and other injuries from explosions and fires caused by arcs and sparks from the trolley system are taken into consideration, that system is unquestionably responsible for at least 10 percent of fatal and large numbers of the nonfatal accidents that now occur in our mines. This is far too heavy a penalty to pay for the supposed efficiency of this method of haulage, and sooner or later either permissible storage locomotives or possibly Diesel engines with suitable safeguarding, or to some extent even compressed-air methods, must supersede the trolley system with its numerous (one could almost say innumerable) hazards.

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More extended use of up-to-date electric cap lamps, which furnish light vastly superior to that formerly available to our miners, certainly has been instrumental in aiding underground workers to protect themselves against accidents from falling material and other causes. Here again, however, changing conditions probably have intervened to help nullify the good effects of the superior lighting afforded by the up-to-date lamps; for example, the increased air dustiness from rapid extension of the use of loading and other machines in confined places in mines has decreased visibility considerably, sometimes as much as 90 percent. The remedy for this is to continue or extend the use of up-to-date electric cap lamps and to adopt methods to decrease air dustiness, such as use of water on the cutting chain of mining machines and other wetting methods or other procedure for air-dust removal. More than 350,000 electric cap lamps are now in use in the coal mines of the United States, but unfortunately by no means all are the up-to-date types with their superior lighting facilities; hence, many of the mine workers, while protected from possible ignitions of gas or dust, are not supplied with as adequate lighting as they could and should be. Out-of-date electric cap lamps, all of which have served their purpose, should go the way of all obsolete equipment, namely, into the scrap pile; ordinary common sense demands that all underground employees should be supplied with the best available lighting system, and today that means electric cap lamps of up-to-date types. About 20,000 of our metal miners now use such lamps, hence are given maximum opportunity to safeguard themselves from accidents insofar as adequate lighting can be of assistance.

The exact savings or profits from the use of up-to-date electric cap lamps are not readily ascertainable, but certainly are appreciable. No explosion or fire has ever been caused by an electric cap lamp; on the other hand, open lights have caused scores of fires and explosions with the loss of hundreds of lives and millions of dollars worth of property. Even flame safety lamps have caused disasters entailing large loss of both life and property. Up-to-date electric cap lamps, with their much greater lighting efficiency than that of lights they displace, permit much more thorough sorting of ore in metal mines and removal of refuse in coal mines than do other types of underground lighting. These advantages are incidental or byproduct results of the use of the lamps, and numerous other benefits in addition to safety can be realized. One mining organization states that chiefly because of the installation of efficient lighting at the face region, accident occurrence was reduced more than 80 percent and cost of coal was cut around 3 cents per ton when the various savings connected with the improved lighting were "lumped." However, electric cap lamps, in spite of their great advantages as to safety, are like virtually every other type of mechanical equipment that goes into a mine, in that they have certain hazards of their own. The worst of these is that they give no warning of the occurrence of explosive, poisonous, or asphyxiating gases. Open lights give no warning of poisonous gases but do warn (too late) of the presence of explosive gases; the same thing may be said about asphyxiating gases, though under some circumstances a certain degree of warning is given by the open light. Some inventive genius should provide us with a safe, dependable, efficient light simultaneously warning on hazards from explosive, poisonous, or asphyxiating atmospheres.

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Safety shoes help materially to prevent injuries in mines from falling or rolling material as well as from numerous other causes. The exact amount of accident prevention as well as savings in compensation and other expenditures through the use of safety shoes is unknown, although it is realized that large numbers of probable injuries (chiefly nonfatal but many with the possibility of total disability or loss of toes or feet) have been prevented.

Wide-awake mining companies now know that the use of goggles is most important in preventing mine accidents, especially those affecting eyes. To promote the use of goggles, some mining companies not only pay for the goggles but also for having employees' eyes examined and sight deficiencies corrected by having suitable lenses put in the goggles furnished the men. In consequence, eye injuries have not only almost ceased to occur, but mines operated by companies that have adopted this humane and far-sighted policy have had very good records in general safety, largely due to the fact that proper lenses in many instances have given employees their first really good vision, hence have enabled them to see more clearly the hazards about them and to protect themselves against those hazards. There is no doubt that the use of goggles can be made universal and there is also no doubt that the safety and efficiency achieved thereby will repay many times over the money spent for goggles.

Gradual elimination of the use of black blasting powder, with fuse and squibs and substitution of permissible explosives and other safety methods have worked wonders in promoting safe mine operation in the United States; the relatively recent campaign of the Department of Mines of West Virginia against the use of any form of black powder in the coal mines of the State has eliminated that source of danger in connection with mining all but about 10 percent of the coal produced, an achievement not only humanitarian but also highly practical from a financial standpoint. From 1906 to 1910, when black powder was used almost exclusively for blasting in American coal mines, the average annual number of fatalities from explosives accidents in bituminous coal mines was 119; from 1931 to 1935, inclusive, with black powder largely eliminated, the average annual number of such fatalities was 23, most of which were due to the use of black powder in some form. These statistics give no information as to the large number of persons killed in coal-mine fires and explosions initiated by black-blasting powder as compared with no explosions and few, if any, fires as a result of using permissible explosives in a permissible manner. Certainly, the use of safety explosives and explosives appurtenances by mining people pays heavily, and, with equal certainty, no type of nonpermissible explosive should be used for any purpose in any coal mine.

Many kinds of mine safety equipment are now available but are utilized to only a limited extent; yet, by well-considered procedure in individual cases, mine efficiency as well as safety is advanced through results obtained from using this equipment. Alabama State inspectors employed gas sampling and analyzing to good advantage to curb gas and dust explosions; a Western coal mine used an aneroid barometer to determine information as to the power consumption of a restricted airway, and as a result of the data obtained

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some widening was done, the cost of which was recovered in the saving in electric power consumed by the fan in 2 years; and the use of a psychrometer in a deep mining region gave data that caused several hundred thousand dollars to be expended to improve the ventilating system, the ultimate benefits to the company and the workers more than offsetting the financial outlay. Dozens of cases could be cited in which the use of safety equipment or the substitution of safe for manifestly unsafe types have brought about substantial savings not only of life and limb but of dollars and cents as well.

The use of safety equipment of all kinds is at least as profitable in the mining industry as in any other industry, and it is remarkable that so little of it is in use in mines. Even the motion picture is highly useful in the prevention of accidents in mines. About 1925 or 1926, a Bureau of Mines safety motion picture was shown in a coal-mining community in Mexico and the titles were translated by an interpreter from English to Spanish for the benefit of the Mexican coal miners. In December 1936, more than 10 years later, an explosion occurred in a mine in the community, and 7 men in one place in the mine and 9 men in another saved their lives by barricading themselves from the poisonous explosion gases by the methods depicted in the film they had seen 10 or more years previously.

Unquestionably, all safety equipment is profitable, but its benefits cannot be realized unless it is used, and up to the present time only part of our mines even attempt to take advantage of the safety equipment available to them. However, accidents cost not only life and limb to their human victims but they also cost money, not only to the victim or his family, or both, but also to his employers and to the general public as well. The already high cost of accidents is going to mount higher and higher as time goes on, as the various State legislatures year by year are increasing the benefits to victims of accidents (soon to include health as well as accident injuries); at least 20 of the State legislatures last year had such increases under consideration. As a result of changes made recently in the Pennsylvania State law, it is computed that under some conditions a single employee fatality may cost the employer as much as $20,000. Some years ago a single fatality cost an Arizona employer more than $45,000. With such possible penalties or taxes staring them in the face (and these benefits are very likely to be raised rather than lowered) the employer who fails to take advantage of available methods and equipment in trying to prevent accidents will soon find himself bankrupt; and at the present time, with the strong tendency to increased mechanization in mining, very few better opportunities offer themselves to the progressive mining man to protect himself, his employees, and his company's stockholders than to see to it that only the safest available equipment is used in and around his mines and that the equipment is kept in safe repair at all times and used as safely as is humanly possible.

Notwithstanding the fact that mechanized contrivances, especially those utilizing electricity, are hazardous in the extreme when used in confined places such as are found almost universally in mines, more and more of them

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will be used to keep pace with other phases of progress in industrial work, including mining. However, the high cost of compensation and of other features of accident occurrence that now are responsible for at least 10 percent of the cost of most of our mineral products and that are likely to cost more owing to the increasing benefits that are being given injured workers through legislative action, will soon force the use of the safest obtainable mechanical equipment. One can confidently predict that in self defense against the mounting cost of accident and health compensation, the alert mine operator of the near future will use only permissible electrical devices and equipment in coal mines, and thereby probably prevent at least 100 fatalities per year. Only permissible explosives fired electrically will be used, and blasting will be done either on the off shift or under the most careful possible supervision if the admittedly unsafe practice of on-shift blasting is utilized, and if this is done it can be counted upon to prevent at least 50 fatalities per year. The open light as well as smoking will be eliminated from underground work and out-of-date, inferior types of lights will be superseded by up-to-date electric cap lamps with a probable prevention of 100 or more fatalities annually. The misnamed flame safety lamp of one gauze, or key-locked types, thousands of which now are in use, will be scrapped, as they should have been years ago, and replaced by either up-to-date methane detectors or at least by permissible flame safety lamps, thus preventing an average of approximately 25 fatalities per year. All of our workers in and around mines or mining plants instead of only some of them will at all times wear protective clothing, especially when underground, this to include safety hats, safety foot and leg wear, and safety goggles (preferably with corrective lenses); if this is done, unquestionably the number of lives saved each year can be increased by at least 100. All, instead of a relatively few, of our coal mines will be rock dusted and the work will be well done and well maintained, thereby continuing to prevent 200 or more persons from being killed by dust explosions every year in the coal mines of the United States. All mines, metal as well as coal, will be ventilated adequately by safe, efficient, mechanically operated mechanisms and this will give reasonable protection to workers against health and other hazards, and will also immunize the mine operator against heavy monetary damage from occupational diseases as well as accidents. No metal-mining man will allow dust-producing equipment, such as dry drills, or use of dust-producing processes, such as blasting, to be employed while the workers are in the mine. Similarly, the alert coal operator will protect his workers against excessive air dustiness by using water on the cutter bar of cutting machines and with loading and conveying equipment. In fact, the time is rapidly approaching when mining people cannot afford to fail to use the safest obtainable equipment and machinery, and this is true even where the first cost or even the operating cost of the safety equipment may be appreciably higher than the cost of buying and operating unprotected, unsafe, worn-out equipment now so generally in use in probably most of our mines.

The use of safe equipment unquestionably pays good dividends in dollars and cents saved the relatively few operating companies that now use such equipment effectively. These savings are reflected not only in relief from

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excessive compensation and hospitalization charges, but in numerous other ways, by no means the least being greater efficiency and productivity due to the better morale of a personnel working under safe conditions. Not only has it been shown that mine safety equipment is profitable when used in an efficient manner, but there is good reason to believe that if State legislatures continue to increase compensation benefits, as has been done more or less steadily in the past several years (and more particularly the past 5 years), with the possibility, even the probability, that many States will soon have compensation laws such that a single fatality may cost the operating company $20,000 or more, as now is said to be the case in Pennsylvania, mine operators will be forced to employ all safety measures, including the purchase and maintenance of only the safest available equipment and machinery. If this is not done, it will be found in many cases that profitable operation will be an impossibility.

A book could be written on the advantages of using safety equipment in mines; certainly our highly mechanized age owes it to those who must use the machines through which our civilazation now functions that such equipment should be as safe as it is possible to make them. Great Britain now requires that the mechanical equipment of factories must be provided with adequate safeguards by the manufacturer, and holds him responsible for failure to provide such safeguards. Our manufacturers eventually will be confronted with a similar requirement, and some of them realize it. In any event, those who operate the mines and are responsible not only for operating costs but also for the safety and health of the workers should certainly take definite steps to provide and maintain none but the safest equipment available.

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